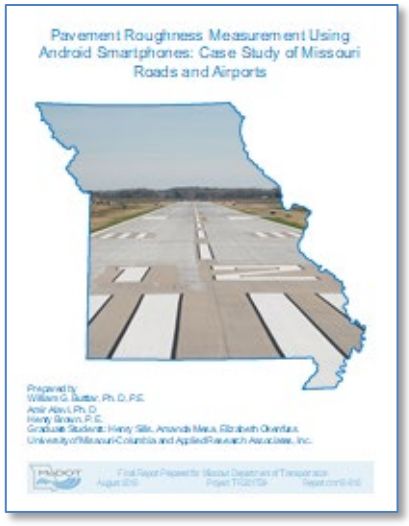
For more information contact: Jennifer Harper (573) 526-3636

Research Summary

Pavement Roughness Measurement Using Android Smartphones: Case Study of Missouri Roads and Airports



Although obtaining data regarding existing airport pavement condition is an essential task for pavement maintenance, pavement condition surveys can be costly and labor intensive. The objective of this study was to investigate the use of an Android smartphone application as a potential low cost and efficient tool to assess airport pavement condition. The smartphone application (app) records vehicle cab acceleration data, a timestamp, and GPS coordinates. The approximate pavement profile is then back-estimated from the acceleration data using an inverse state space model. The model considers the physics of the mass-spring-damper system of the vehicle sprung mass. The analyses were performed using a MATLAB script to calculate the IRI values.

The initial phase of this study focused on the validation of this monitoring technology for pavements in Missouri. To this end, the smartphone-measured IRI values were obtained for test sections of I-70 near Columbia, MO and compared with known IRI values measured by MoDOT's Automatic Road Analyzer (ARAN) van. The validation showed that the smartphone application performed well in estimating the IRI of the test sections. The measured IRI data accurately classified the pavement condition based on MAP-21 requirements.

In the second phase, the proposed technology was implemented to determine the IRI values at Missouri Airports. First, a calibration study was performed on a designated test section of MO-10E near Excelsior Springs, Missouri to find the optimal model parameters. Then, the smartphone application was used to collect acceleration data for airport pavements at the 27 state funded general aviation airports in Missouri. Each test run was conducted multiple times over right, centerline and left lanes of the airfield pavements. Finally, an extensive analysis was performed to calculate the IRI values for the airports. In order to reduce the uncertainties, only one smartphone model (Samsung Galaxy S8), one type of smartphone car mount, and one vehicle type (SUV) was used for data collection through the entire project.

It was observed that the IRI values ranged from 47 to 280 for the airfield pavements. Among the investigated airports, Bollinger-Crass Memorial Airport in Van Buren with an average IRI equal to 59 inch/mile was found to be in very good condition. Bonne Terre Municipal Airport pavement was found to have the highest roughness, with an average IRI of 227 inch/mile on the centerline lane. The remaining airports were classified as follows with respect to

pavement condition assessed via the smartphone app: 10 airports in good condition, 13 airports in fair condition, and 2 airports in poor condition.

"The study found that the smartphone application has the potential to be an effective low cost tool for assessing airport pavement condition."

The validation results indicated that the IRI values measured by the smartphone were in good agreement with the ARAN-measured IRI. The obtained trends agreed well with the construction and maintenance records of the airports. An equation was developed to predict PCI based on the IRI values measured from the smartphone application. With a modest amount of app user interface development, the developed app and analytics could be used by airport managers to assess and track runway condition, and by MoDOT to prioritize scheduling of PCI surveys and to prioritize maintenance activities and investment.

The research presented in this study can be enhanced in several ways. For example, a more robust approach could be developed by including a large number of smartphones and a fleet of vehicles to collect pavement roughness data through crowd sourcing. In addition, estimating IRI based on aircraft cab acceleration data may lead to more realistic results and deserves study. Finally, finding a sound correlation between the smartphone-based IRI, PCI and Boeing Bump Index (BBI) could be an interesting topic for future research.

The pilot study at four airports using the low-cost, PaVision system, did not perform as hoped based on the existing algorithms developed for roads. However, preliminary efforts indicated that applying new machine learning algorithms could improve the performance of the PaVision system. Further research with larger data sets would be needed to determine if new approaches to developing algorithms could improve PaVision performance to a level that it becomes a useful tool for evaluating pavement conditions in the airport environment.

Project Information

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Project Manager

Jennifer Harper, P.E., PMP
Research Administrator
Missouri Dept. of Transportation
Construction & Materials Research Section
1617 Missouri Blvd
Jefferson City, MO 65109
(573) 526-4328
Jennifer.Harper@modot.mo.gov